

Enhancing Thermal Conduction in Liquid-based Cooling Systems Used in Performance Computing Using Structured Phonon Injection Within Coolant Tube Walls

27 January 2025

Simon Edwards

Research Acceleration Initiative

Introduction

Liquid-based cooling systems are limited by the efficiency of heat transfer between chilling tubes and processors. Thermal gradients of too great a severity can damage electronics and are undesirable. What is desired is the ability to encourage the conduction of heat across the boundary between processor and coolant so that a processor can be chilled by a coolant of a less extreme temperature which is kept cold through a more affordable process. The more efficient the heat transfer between the coolant and the hardware, the less cold one needs to make the coolant and the more efficient the whole process becomes. Phonons and their behavior are critical for maximizing the efficiency of this process both at the boundary of processor and coolant tube as well as within the processors themselves.

Abstract

Phonons are often overlooked in discussions about cooling and when they are discussed, they are discussed in the context of something which should be mitigated as they tend to lead to the generation of heat. Structured phonons, I would posit, can be used in order to enhance thermal conduction and do not necessarily always contribute to heating but can, rather, be strategically employed in order to contribute to cooling.

In prior publications, I have described how an interweaved architecture two-core processor can be used to alternate the use of transistors doped to purposefully generate acoustic energy. Transistors in alternating squares, if the processor space is visualized in such a manner, can be selectively turned off with "A" and "B" sets of transistors being used alternately with the A and B sets residing roughly in areas looking like the red and black squares on a checkerboard. By alternating between the A and B sets roughly 20 times per second and by deliberately introducing phononic energy, I explained how sound can be used to sweep heat to the periphery of the processing unit more efficiently. This, I would argue, makes more sense than the use of discrete processing cores in which areas equivalent to 75% or more of the entire processor are shut down for three or four seconds at a time in order to reduce heating.

Building upon this understanding, it should be possible to augment traditional liquid cooling systems by manufacturing coolant tubes which not only conform to the shape of the hardware so as to maximize the surface area in contact with the tubes (these are not literally tubes in this day and age, but, rather, are thin, flat envelopes filled with a circulating fluid composed of materials which conduct heat much better than plastic.

At the boundary between these envelopes and the hardware, itself, such an envelope or “tube,” if you will, might, I propose, be made to project structured phononic energy from its surface in a circulating pattern moving toward the hardware to be cooled and looping back to the envelope after traveling just a few nanometers. Strong percussive waves, for example, follow a linear path. Phononic energy does not degenerate into heat until its terminal phase, which entails its flow pattern devolving into circulating swirls.

These swirls; if purposefully generated at low intensity at the boundary between two disparate materials; can enhance the efficiency of heat conduction at that boundary. Rotating phononic energy is, in many ways, to sound and heat what a metamaterial is to a material. Just as metamaterials exhibit different properties depending upon their configuration relative to other materials and ambient conditions, rotating phononic energy exists in a limbo between being sound and being heat. For it to be heat, it would have to be capable of generating a net increase in temperature which it does not do, as it is circular. For it to be sound, it has to be capable of traveling over distance. Rotating phononic energy does not truly do this.

In a manner of speaking, the creation of *this sort of structured phononic activity can allow for heat, itself, to act as a catalyst for the further conduction of heat* without causing the undesired effect of introducing more heat energy to a system than was in the system in the first place. As this energy is being introduced at the boundary between a relatively hot system and a relatively cold system, it serves to enhance conduction and leads to more rapid cooling of the processor, in this case.

In order to generate these effects, it would be necessary to dope the envelope material with crystalline materials capable of converting ambient acoustic energy (plentiful in the proposed environment) into alternating Coulomb Force Lines, which have a strong tendency toward introducing asymmetrical phononic actuation of atoms of the sort tending to lead to the introduction of these swirling pockets of sound energy at the nano-scale whilst also having the effect of absorbing a small portion of the ambient acoustic energy which might lead to undesired heating.

Conclusion

Although this particular implementation is likely to provide only slight improvements to overall computing efficiency, this understanding, when implemented in multiple domains could lead to more efficient overall systems whereas some of those other domains have already been delineated by this author. Enhancing thermal conductivity at the boundary of coolant envelopes is merely one part of an overall strategy for promoting the cooling of processors.